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PROGRESS REPORT ON THE BIOLOGY OF CYLINDROCOPTURUS LONGULUS LEC. IN PONDEROSA AND JEFFREY PINE REPRODUCTION

by
C. B. Eaton
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Forest Insect Laboratory
Berkeley, California
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PROGRESS REPORT ON THE BIOLOGY OF *CYLINDROCOPTURUS LONGULUS* LEC. IN PONDEROSA AND JEFFREY PINE REPRODUCTION

APPROVED BY:

J. M. MILLER
Senior Entomologist, In Charge

SUBMITTED BY:

C. B. EATON
Junior Entomologist

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PROGRESS REPORT ON THE BIOLOGY OF CYLINDROCOPTURUS LONGULUS LEC. IN PONDEROSA AND JEFFREY PINE REPRODUCTION *

INTRODUCTION

Overshadowed by the more spectacular types of damage resulting from the activities of insects infesting mature timber, the depredations of insects affecting reproduction and second growth trees in the pine forests of northeastern California have received comparatively little investigation by forest entomologists. While it is quite logical that the greater portion of present forest insect research should be directed toward reducing losses in forest stands where the greater present day values lie, entomologists cannot overlook the fact that future timber values exist in reproduction and the younger age classes. The combined effects of fire, logging, and insect activity in reducing the supply of virgin timber will eventually force a reversal of the present concept of values, with the result that sooner or later more emphasis in research will be placed on insects affecting the younger age classes. The series of events which brought about the initiation of investigations on the weevil Cylindrocopturus longulus Lec., with which this report is concerned, is one instance of this shift in emphasis.

Prior to the last few years forest entomologists in the northeastern part of California have seldom been called upon to focus their attention on forest plantings, for the simple reason that this method of securing a stand of trees on an untimbered area has been introduced in this region in relatively recent times. Incidental records have been made from time to time on various insects attacking natural reproduction, but no intensive investigations have been made. Consequently reports by members of the U. S. Forest Service in 1938 of insect damage to young ponderosa and Jeffrey pine trees planted in the Big Springs brushfield (Figure 1), Lassen National Forest, found us completely at loss to say even what insect was involved, or whether or not it was responsible for the injury. The damage even at that time was severe enough to have warranted earlier investigations, but because of the pressure of other jobs, studies could not be started until this season.

In view of the initial expense involved in establishing tree species by the stripping and planting method (Figure 2), it is felt that the damage in this one plantation has been severe enough to warrant the entomological studies made this year. The work is further justified by the scarcity of information on this and other insects of similar habits which

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* This project was conducted by the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, in cooperation with the Forest Service. Supervision was furnished by the Berkeley Station, while facilities for field work were available at the Hat Creek Field Laboratory. Acknowledgement is made to Dr. C. T. Rumbold, Bureau of Plant Industry, for culturing and identifying fungi from material collected in this study.

Figure 1. This scene, Big Springs Brushfield, is typical of brushfield areas in which attempts are being made to secure a forest stand by planting young pine trees. (11243)

Figure 2. Rows like this are cleared through the manzanita with a bull dozer to provide space for planting. (112321)

attack the younger age classes in the ponderosa pine region. In addition the study is justified by the expectation that the information obtained will be applicable to other areas and will be useful for the protection of other plantations.

TAXONOMIC POSITION OF THE WEEVIL

The weevil (Figure 3) with which this study is concerned was determined by L. L. Buchanan as belonging to the genus Cylindrocopturus Heller and species longulus Leconte. It is a member of the family Curculionidae, order Coleoptera. In commenting on the specimens sent in for identification, Buchanan indicated that there was considerable variation in the markings of the material in the Museum series. References in literature on the taxonomy of the species reveal that there is wide variation in the species. Van Dyke (1930) mentions that C. longulus is very variable in color pattern and host plants. He considered the five species listed by Casey from coniferous trees as color varieties of C. longulus. The several species proposed do not appear to have received recognition by other investigators, for little mention of them is found in literature on the Cylindrocopturus group. In view of the variable habits reported, the writer is inclined to believe that the taxonomy of C. longulus may bear closer scrutiny.*

HISTORICAL REFERENCES

Published Records

As far as the writer has been able to determine there are few published records of injury by Cylindrocopturus longulus to tree seedlings of any kind. Keen (1928) reports that the weevil lays its eggs in the bark of dead and dying pines, and that the larvae feed on the bark. Van Dyke (1930) says that typical C. longulus breeds in Douglas fir, lodgepole pine, and true firs, and that it has been taken from Monterey pine. Doane et al (1936) indicate that the species breeds freely in twigs of various species of pine, true firs, and Douglas fir, and that it has been reported on several occasions to have caused considerable damage.

Unpublished Miscellaneous Records

The first record in the files of the Berkeley Forest Insect Laboratory on Cylindrocopturus longulus was made by F. B. Herbert early in 1916. Since that time thirteen entries concerning this particular species have been made. According to these records the weevil has been taken from various parts (mostly twigs and bark) of the following trees: ponderosa pine, Douglas fir, spruce, fir, Jeffrey pine, lodgepole pine, and sugar pine. Most of the records indicate that the weevil is secondary in pine. However Miller and Salman recovered it from gall-bearing twigs and branches of Jeffrey pine collected on the Lassen National Forest in 1931, and are

* See Addenda, page 18.

Figure 3. This is the weevil that causes the damage. The adults feed on pine foliage before they attack twigs and stems. (11231d)

Figure 4. Vigorously growing Jeffrey pine transplants like this are readily killed. (11232k)

inclined to agree that the activity of the weevil caused the gall formation (Salman, 1939). In this particular case the galls were not caused by pathological organisms, according to Pathologist W. W. Wagener.

There are only four records of C. longulus causing damage to seedlings and small reproduction similar to that occurring at Big Springs, (Figure 4). In these instances the injury was found in natural reproduction. Three of the records refer to injury to one or two individual trees in widely separated parts of the state. The fourth report of small sugar pine reproduction being killed in Ackerson Valley, Yosemite National Park, in 1934, is most nearly like the type of damage encountered in the Big Springs area. In only one case has injury to nursery or planted stock been reported previously: a 2-0 Pinus scopulorum seedling was found in the nursery at the Institute of Forest Genetics, Placerville, California, in 1930 from which weevils were reared which were identified by H. E. Burke as belonging to the genus Cylindrocopturus.

Unpublished records from the Portland, Oregon, Forest Insect Laboratory, reveal that C. longulus is the most common insect associated with dying Douglas fir in the Puget Sound Basin (Furniss, 1939 a). In this instance the insect was found attacking and killing small twigs of open-grown reproduction less than 25 feet in height. Furniss indicates that dry weather, in this particular instance, is the most important factor in bringing about outbreaks of the weevil, and suggests that its abundance is associated with the low vigor of the attacked trees.

History of the Big Springs Infestation

The first indication of injury in the Big Springs plantings, Lassen National Forest, was reported in the fall of 1938 by E. E. Horn, Bureau of Biological Survey. In the course of investigations on rodent damage, Horn encountered serious losses in the plantings of 1932-33 where many dead and dying pine trees were counted. Various stages of mortality were encountered. Some trees were completely dead, others partly dead, with most of the needles brown and the twigs and branches brittle. Horn also noted that the cambium of the injured trees was dark and partly filled with resin, but that the root systems were to all appearances normal and healthy, with no sign of injury. He stated that "boring insects" were present in all the trees examined.

W. W. Wagener, Bureau of Plant Industry, examined the plantings at the same time, but found no evidence that a plant disease was responsible for the losses.

Unfavorable climatic and site factors were suggested by various parties as possible explanations for the mortality, but partial records of weather and site factors taken by the California Forest and Range Experiment Station, do not, according to Duncan Dunning (1938) provide a basis for linking these factors with the injury. Dunning's data indicate that the season

of 1937 was exceptionally favorable in this area, and that the season of 1938, while drier than that of 1937, was not particularly severe. Planting stock was grown from seed collected at Chester, a comparatively short distance away, thus the suggested factor of seed source did not appear to be important.

K. A. Salman examined the plantings in October, 1938, and found the twigs and stems of the dead trees infested with small white grubs. Forced rearing of infested material in Berkeley during the winter of 1938-1939 showed that Cylindrocopturus longulus Lec. was the insect involved.

Due to lack of knowledge of any previous activity of this sort where this particular weevil was involved, it was hardly possible to make any control recommendations. Little was known of the life history and habits of the insect, whether or not it could be entirely responsible for the damage, whether it would be likely to be encountered in other plantations, or what could be done in the way of control. Under these circumstances practically the only course open was that of conducting investigative work to uncover information on these points.

DESCRIPTION OF LIFE STAGES

Adult

As encountered in the field the superficial appearance and extreme activity of the adult C. longulus remind one of a leaf hopper. However, closer examination shows that the insect is a small boat-shaped weevil, about 1.5 to 2 mm. long. The body is covered with small scales having a metalic luster. The scales on the ventral surface are usually uniformly gun metal gray in color. The wing covers present a variegated appearance due to the interspersion of dark brown scales with the gray. The dorsal part of the thorax is generally dark brown, with a few light scales on the sides. The legs are grayish in appearance and also scaly. The beak is dark brown in color, but smooth. Newly emerged adults are lighter colored and brighter in appearance than are older ones.

As far as the writer has been able to determine, there are few external characters to distinguish the sexes. The main difference is the degree of depression of the first abdominal sternite. In the males this sternite is more or less concave in the center, whereas in the females it is usually convex or only slightly flattened. A random group of one hundred adult weevils separated by means of this character fell into two lots of 50 males and 50 females each. The sex ratio is therefore 0.5.

Egg

The eggs of this weevil are minute, pear-shaped structures barely visible to the naked eye. When first deposited they are nearly

transparent in appearance, and are extremely difficult to distinguish from the fresh droplets of resin in the cortex of the host tree in which they are laid. As incubation progresses the eggs become more rounded in shape, and assume a whitish appearance.

Larva

The larvae are small, legless grubs, about 4 mm. long when fully grown. The head is light brown in color with distinct eyespots on either side. The general color of the body varies from white in the younger larvae to cream-colored in mature larvae.

Pupa

The pupae are slightly larger than the adults, about 3 mm. long, and are cream-colored in appearance.

OBSERVATIONS ON THE LIFE HISTORY

Preliminary data on the life history and some of the habits of the weevil C. longulus have been obtained as a result of rearing studies at Hat Creek and observations at Big Springs. It should be noted that these data are based on the results of one season's work, and because of the fact that the season of 1939 was drier and warmer than usual, the life history as depicted may vary from the normal in some of the details.

Overwintering Habits

The weevil overwinters in the larval stage in twigs and the outer sapwood of the stems of infested pine reproduction. The 1938-1939 brood consisted largely of half grown larvae which the writer believes is the normal overwintering stage in this locality. However, the 1939-1940 brood was fully developed by the end of the summer and is overwintering as full grown larvae. No eggs or pupae have been found holding over in infested trees, but it is possible that a few adults emerging late from the previous year's brood or developing rapidly from the current brood may overwinter. This possibility is mentioned because of the fact that a few adults were encountered in infested trees late in the season, but none were found later on in early winter. It is concluded that some weevils emerged and are overwintering in the adult stage. However, none were seen in the field prior to emergence last spring, nor have any been encountered this fall outside the pupal chambers of infested trees.

Pupation

The larvae resume feeding for a short time during the warmer weather in early spring, but finally become inactive as they reach the prepupal state. Pupae were first noted in the field the third week in April, while the first emerging adults were observed during the last week in May. The length of the pupal period for individual weevils is probably somewhat shorter than this. Occasional pupae were taken as late as the middle of June from parts of the tree above ground. Pupae were removed from portions of the stem above the root collar, but below the ground level, as late as the first week in July.

Emergence

The first weevils collected at Big Springs were taken on May 27. Emergence from that date on became progressively greater until about the third week in June when the weevils were the most numerous in the field. By the first of July no infested seedlings could be found which contained unemerged brood in parts of the tree above ground. Adults were numerous on nearby green reproduction for some time after this, but decreased considerably in abundance by the last week in July. No active adults were seen in the plantation after the first week in August.

In order to determine what differences exist in the proportion of weevils emerging from various parts of the infested trees, material containing the 1938 brood was collected and placed in rearing in the spring of 1939. The stems and twigs were segregated, the latter according to season of growth. When emergence had occurred, the total number of weevils for each lot was counted and the total length and average diameter of twigs and stems measured. These data were used to compute the emergence from each lot on both an area and a volume basis (Table 1).

Table 1. Summary of Emergence of *Cylindrocopturus* Weevils Twigs and Stems of Ponderosa and Jeffrey Pines

Emergence From	Area Sample (sq.in)	Volume Sample (cu.in.)	Total Number Adults	Emergence Per 10 sq. in.	Emergence Per cu. in. Wood
1936 Twigs	136.7	8.65	74	5	9
1937 Twigs	328.9	14.95	208	6	14
1938 Twigs	422.9	15.96	115	3	7
Stems	494.1	51.24	1255	25	24

This tabulation shows that the emergence from stems was considerably greater than that from twigs whether figured on an area or on a volume basis. From the 1938 twigs, which constituted the current growth at the time of attack, the emergence was not as great as that from older twigs.

Adult Activity

Observations on the activities of C. longulus adults were made largely through the use of modified Riley type cages (Figure 5) in which the weevils were confined with green trees. The insects are active, wary individuals running and flying with unexpected agility and speed. When resting and feeding on the needles and twigs, they are very difficult to see because of their small size and indistinctive markings. Due to their characteristic habit of playing dead the mature weevils are easily collected in quantity by beating the trees on which they are resting. They do not seem to react strongly to light, for in rearing experiments part of the emerging brood came to the collecting tubes and part remained behind. In the several observation cages set up no reaction to the position of the sun could be detected.

There seem to be some differences in the feeding habits as the weevils age. Newly emerged adults observed on caged trees did not at first feed on the stems or twigs of the host, but settled down on the needles instead (Figure 3). A hole was first chewed through the epidermis of the needle and the internal cells then eaten away beneath and peripheral to the hole for as great a distance as the weevil could reach with its beak, usually about ½ mm. As the beetles grew older they appeared to develop a preference for the tender green bark of the newly formed twigs instead of the foliage (Figure 6). Feeding pits were found in the cortex of the twigs and stem which were excavated in a manner similar to those on the needles. Interspersed between the feeding pits, cavities containing eggs were found.

The eggs are laid in the cortex of both the twigs and stems of pine reproduction. The female weevil excavates in the outer part of the cortical layer a small cavity just large enough to accommodate the egg. One egg is deposited in each cavity. Located as they are in living plant tissue interspersed with droplets of resin, the eggs are difficult to distinguish. In the small green twigs they are very slightly protected because of their proximity to the surface. The writer has failed thus far to find any eggs deposited in dead or dry tissue; oviposition apparently occurs only in living material.

Larval Development

Following the discovery of eggs of the species in the field in early July, collections of larvae were made biweekly for the balance of

Figure 5. Modified Riley cages were used for observation on activities of adult weevils on naturally established seedlings. (11231a)

Figure 6. Numerous globules of resin are formed on twigs and stems of healthy trees when cortex is punctured by feeding of adult weevil. (11232f)

the season. The purpose of this work was to provide material for determining the number of larval instars, and to furnish some basis for dating larval development and progress of damage to the host trees. It is to be regretted that more frequent collections were not made during the first month or so after the egg stage was discovered, however, it is believed that the data obtained is sufficient to indicate the progress of larval activity. External changes in the host trees were observed periodically in the field and can be tied in with larval development.

<u>Number of Instars:</u> The number of larval instars was determined by measuring the head capsule widths of larvae collected at random from the general population. On larger insects the number of larval instars may be determined by direct observation of the number of molts, or by collecting exuviae from the larval galleries. However, the small size and concealed mode of existence of the weevil precluded the use of either of these methods, and resort was made to head capsule measurements. This method has been used successfully by Bedard (1933), Salman (1934), Becker (1939), and others with various species of scolytids.

Variously aged larvae were obtained from material collected at each biweekly sampling period as previously mentioned. This material was preserved in alcohol and measurements were made later with an ocular micrometer. Twenty-five larvae from each of the first five samples taken and 25 from the last sampling of the season were selected for measurement. Additional measurements from samples taken during the latter part of the season were considered unnecessary because of the uniform size and lack of further development of the larvae at that time. The head capsule widths of 150 larvae measured ranged from 0.144 mm. to 0.696 mm. in dimension. The frequency distribution of this series of measurements is plotted in Figure 7. The triple peaked graph which results is interpreted by the author to indicate three instars for the larvae of this species. It is fairly certain that the first peak represents the first instar because the larvae to which these data apply were practically all collected at the first sampling period on July 14, when a considerable number of unhatched eggs were found in the same material. Furthermore, many of the larvae had hardly begun to mine at this time. It is considered that the last peak represents the last instar because of the lack of variation in head capsule measurements of larvae collected the latter part of the season, indicating that larval development had ceased. In addition the fact that a few larvae pupated early in September leads the writer to believe that the general larval population was near the prepupal stage when winter set in. The middle peak in the graph occurs very nearly half way between the first and last, and is distinctive enough to indicate a second instar, although more data would have been desirable. The variations in the first and last peaks are considered minor.

By dividing the data on which this graph is based into three groups, assuming that the mid-points in the depressions between the peaks represent the instar boundaries, the mean head capsule width for each instar can be computed. A summary of this computation is presented in the following table:

Figure 7

FREQUENCY DISTRIBUTION OF HEAD WIDTHS OF CYLINDROCOPTURUS LARVAE

BASIS - 150 MEASUREMENTS

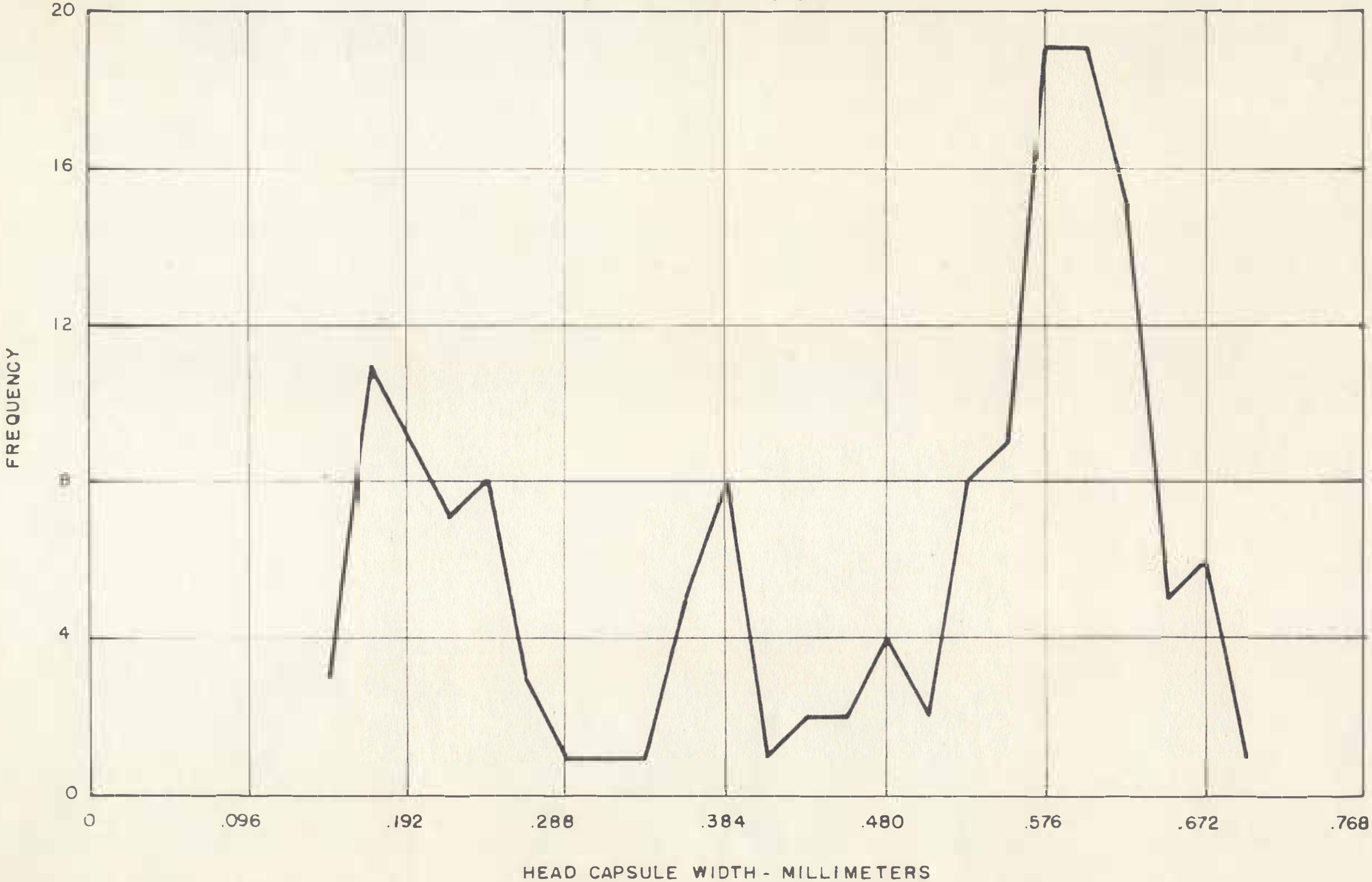


Figure 8. The puntures in these needles were caused by the feeding of the adult weevil. (11232L)

Table 2. Mean Head Capsule Measurements for Various Instars of *Cylindrocopturus longulus*.

Instar	Individuals Measured	Mean	Head Capsule Width		
			Stand. Dev.	Maximum	Minimum
1	42	0.203 mm.	±0.037 mm.	0.288 mm.	0.144 mm.
2	18	0.377	±0.029	0.432	0.312
3	90	0.536	±0.051	0.696	0.456

Larval Activity: By the third week in July most of the eggs had hatched. The tiny larvae mined for some time in the cortical layer, cutting out small galleries which they filled with brown resinous frass. Later as the larvae grew larger, the mines ran together destroying the entire cortical layer, and eventually the phloem. When the phloem material became well worked over and commenced to dry out, the larvae entered the outer rings of wood where they mined out galleries at various depths, usually remaining within a short distance of the surface in the larger stems. By the end of the season nearly all the larvae had formed pupal chambers in the wood. The habits of the larvae in the smaller twigs differed from the above in that they descended more directly to the pith and spent the remainder of the season mining around in the pith.

The majority of the weevil population is passing the present winter in the mature larval stage. However, a few individuals matured this fall. In samples taken from the general population on August 25, a few pupae were collected. Prior to this time no pupae had been encountered since the transformation to the adult stage of the parent generation. Again on September 8, pupae were found, and on September 21 both pupae and callow adults were collected. At the subsequent sampling period two weeks later, a few adults were found in the pupal chambers in the wood, but in the last two collections of the season no additional specimens of either of these two stages were found. While failure to find adults and pupae at the end of the season may be due to faulty observation, the writer is inclined to believe that the few individuals which developed to the adult stage later emerged.

INJURY TO PINE SEEDLINGS

Types of Damage

Injury to the host is caused by the feeding habits of both the adults and the larvae. The feeding habits of the adults have already been described. Only in unusual cases are the feeding spots on the foliage (Figure 8) sufficiently numerous to cause the death of the foliage. In rare instances adult feeding on the needles and twigs has been observed to

cause flagging of individual shoots. Resistance to attacks of the weevil is usually evident in the form of droplets of resin exuded along the stem, where feeding and oviposition has occurred (Figure 6). These resin droplets are very conspicuous on freshly attacked trees, but become less apparent as the resin dries and turns white. Feeding on the foliage of large trees has been noted in one or two instances where no accompanying larval damage was found.

In the stem, the mines of the larvae completely destroy the cortex and phloem, and also riddle the outer layers of wood (Figures 9 and 10). In the smaller twigs the larvae usually hollow out the interior to such an extent that the twigs are readily broken off. Mining of the small larvae beneath the needle sheaths causes early shedding of the foliage of infested trees. Unsuccessful attacks on green trees may result in the killing of a patch of tissue here and there on the stem. These dead patches are dried and resinous, and contain numerous dead larvae apparently drowned by the resin flow.

Referring to the gall-forming habit attributed to this weevil by Salman (19[illegible]), no evidence has been found in this study which would confirm this report. Injury of this kind did not develop on Jeffrey pine trees used in forced attack studies, nor have galls been encountered on infested trees in the Hat Creek area.

Evidence of Injury

The external effects of weevil injury on attacked trees are first apparent in the terminal and lateral shoots which shrivel and dry up as the foliage yellows and turns brown. As the larvae develop, browning of the foliage occurs progressively from the top downward. These effects are accompanied by discoloration and deterioration of the phloem due to larval activity. The roots remain green for some time after the top turns brown. Occasional trees are merely topkilled, with the lower branches surviving. Also a few trees survive for a short time through the development of adventitious buds near the ground. However, these weakened individuals seem to be particularly susceptible to attack by the succeeding generation of weevils.

This season ponderosa and Jeffrey pine transplants at Big Springs showed first signs of fading during the second week in August, four to five weeks after attack. By the first of September many newly faded trees were present, and by the end of the season the majority of the currently infested trees were red. It is doubtful that the injury progresses as rapidly every year, for during the previous season many trees did not begin to fade until spring.

Seedlings killed by this weevil usually deteriorate with extreme rapidity. Two years after attack practically nothing is left of the infested trees except the main stem and larger twigs riddled with emergence

holes (Figures 11 and 12). Most of the needles fall off the first winter after emergence. Faded trees may occur toward the end of the season in the same planting which were actually killed in two consecutive seasons. However, the individuals killed by the current generation will not bear emergence holes, whereas those killed the previous season will.

Forced Attack Studies

The ability of the weevil to kill seedlings of different tree species was tested in forced attack studies made this season in natural reproduction at Big Springs. Prior to emergence of the 1939 brood, infested material was caged with healthy appearing hosts in the manner illustrated in Figures 13 and 14. Douglas fir, ponderosa, Jeffrey and sugar pines were used in the experiment. A summary of the results of these tests is given in the following table:

Table 3. Summary of Results of Forced Attack Tests to Check on the Ability of C. longulus to Kill Different Species of Tree Seedlings.

Tree Species	Date Infested	Number of Trees Infested	Mortality: Number of Trees	Mortality: Percent
Ponderosa pine	5-27-39	10	7	70.0
Jeffrey pine	4-21-39	7	5	71.4
Douglas fir	5-31-39	2*	0	0
Sugar pine	5-31-39	1*	0	0

*Severely injured by feeding on needles and twigs, but apparently recovering.

These data show that death resulted in nearly three-fourths of the cases where ponderosa and Jeffrey pine were used. The douglas fir and sugar pine were severely injured by feeding of the adult weevil, but brood was not established in either case, and the trees appear to be recovering. Tests on these last two species will bear repeating due to the lack of sufficient replications to make the results conclusive. It is not considered that the cages exert any great deleterious temperature effects on the plants, for air temperature records indicated that the outside air was 10° F. hotter than that within the cage during the hottest part of the day. None of the cages were continuously in the sun, but were intermittently shaded by larger trees.

Figure 9. Weevil larvae mine in stem down to root crown. They do not mine into roots. (11232g)

Figure 10. Mines of larvae riddle wood to pith in small twigs like this. (11232j)

Figure 11. Segment of pine transplant killed and abandoned by weevil. Note emergence holes. (11232h)

Figure 12. Deterioration of weevil killed trees is rapid. This picture was taken 18 months after attack. (11232e)

Figure 13. Pine seedlings dying from attacks of the weevil are occasionally found in natural reproduction. The seedling at right was killed by Cylindrocopturus. (11232c)

Figure 14. Forced attack experiments show that mortality of apparently healthy yellow pine trees results 7 times out of 10. Muslin cages (right) were used to confine weevil to tree. (11231b)

Four ponderosa pine seedlings were partially or completely mechanically girdled at the time infested to check on the effects of mechanical injury and subsequent success of attack. No greater mortality was sustained by the injured trees than by the healthy trees. It is concluded, therefore, that mechanical injury is not directly related to success of attack by the weevil.

ASSOCIATED ORGANISMS

Insects

Like many other insects, C. longulus is host to a number of native insect parasites which undoubtedly play a part in keeping the insect in check under natural conditions. A series of representatives of all parasites collected in connection with rearing studies has been submitted for identification.* No predatory species were encountered.

Occasional trees attacked by the weevil at Big Springs plantation were found to be hosts to other insects which were apparently associated with the weevil by accident. The most frequently encountered insects were the weevil Magdalis lecontei Horn in the tips of twigs, and an aphid (unidentified) on the twigs and stems. Evidences of tip moth injury were found, but no specimens obtained.

Fungi

One of the characteristics of the infested material first noted by the writer in examinations made during the winter of 1938-1939, was the heavy blue-staining of the wood. In May, 1939, several Jeffrey pine seedlings from the Big Springs plantation, infested with C. longulus were sent to Dr. C. T. Rumbold, Bureau of Plant Industry, for examination. Dr. Rumbold reported (1939) that the fungus Hormiscium gelatinosum Hedgc. developed in the majority of cases where cultures were made of wood, bark, larvae, pupae, and dead adults, as well as from feeding spots in the needles. Since it is associated with all active stages of the weevil, the fungus probably plays an important part in bringing about the death of the tree. The fact that it was recoverable in a high percentage of cases from adults and from spots on the needles caused by adult feeding, indicates that the spread from diseased to healthy trees may be dependent on activities of the insect. The fungus is reported to be of economic importance in the staining of lumber.

Dr. G. A. Zentmeyer, Bureau of Plant Industry, isolated the fungus from both planted and native diseased stock infested with C. longulus at Big Springs. He also found the fungus infection in discolored cortical patches sometimes entirely surrounded by green tissue, and usually on trees which had been previously topkilled. The writer has observed these discolored, roughened areas on healthy appearing trees as well. The indications

* See Addenda, page 18.

are that these patches are areas where adult feeding and oviposition has occurred, inoculating the tissue with the fungus. The development of the brood has been unsuccessful, and the tissue impregnated with resin. These observations are supported by the fact that the remains of dead larvae can frequently be recovered from the darkened cortical patches. Zentmeyer found the fungus <u>Hormiscium gelatinosum</u> almost universally associated with the weevil in the Hat Creek area. The pathogenicity of the fungus, independent of the insect, has not yet been demonstrated.

SUMMARY OF DAMAGE

<u>Big Springs Plantation</u>

Two loss surveys were made of the Big Springs plantings during the 1939 season. One was completed during the first week of July, before the 1939 injury became evident, and the second was made early in November when most of the trees attacked during the summer had become well faded. Trees killed in 1938 were easily recognizable in the first survey, but those killed prior to 1938 could not be distinguished by time of death, due to their rapid deterioration. In making these surveys, random counts were made in each of the different aged plantings, and a tally kept of the number of living and dead trees by species, and date of death. No trees were included in the counts which showed evidence of death due to other causes, so that the survey covers only living and weevil-killed trees. The loss figures are therefore based on the number of trees living at the time weevil attacks first took place, and not on the number of trees originally planted.

A summary of the results of these surveys is given in table 4, and in the accompanying graph (Figure 15). These data show that the highest losses have thus far occurred in the older plantings, and that the latter were hit the earliest. The figures indicate that the 1937 plantings have escaped injury, however over the entire area of plantings of this date, an occasional infested tree may be found. Comparing the two species, ponderosa pine has suffered a much greater mortality than Jeffrey, since over 90 percent of the 1932-1933 plantings of the former species have been killed, as compared to more than 70 percent for the latter species.

There does not appear to be any particular selection of trees injured. The individuals most commonly killed in the 1932-1933 plantings range from 2 to 3 feet in height and are to all appearances healthy. In growth there is no evidence that any deleterious environmental factors predispose the trees to injury. The larger trees have succumbed as readily as the smaller ones, and if anything, more of the runty individuals than the healthy escape.

Figure 15

SEEDLING MORTALITY DUE TO CYLINDROCOPTURUS ACTIVITY
BIG SPRINGS PLANTATION, LASSEN NATIONAL FOREST

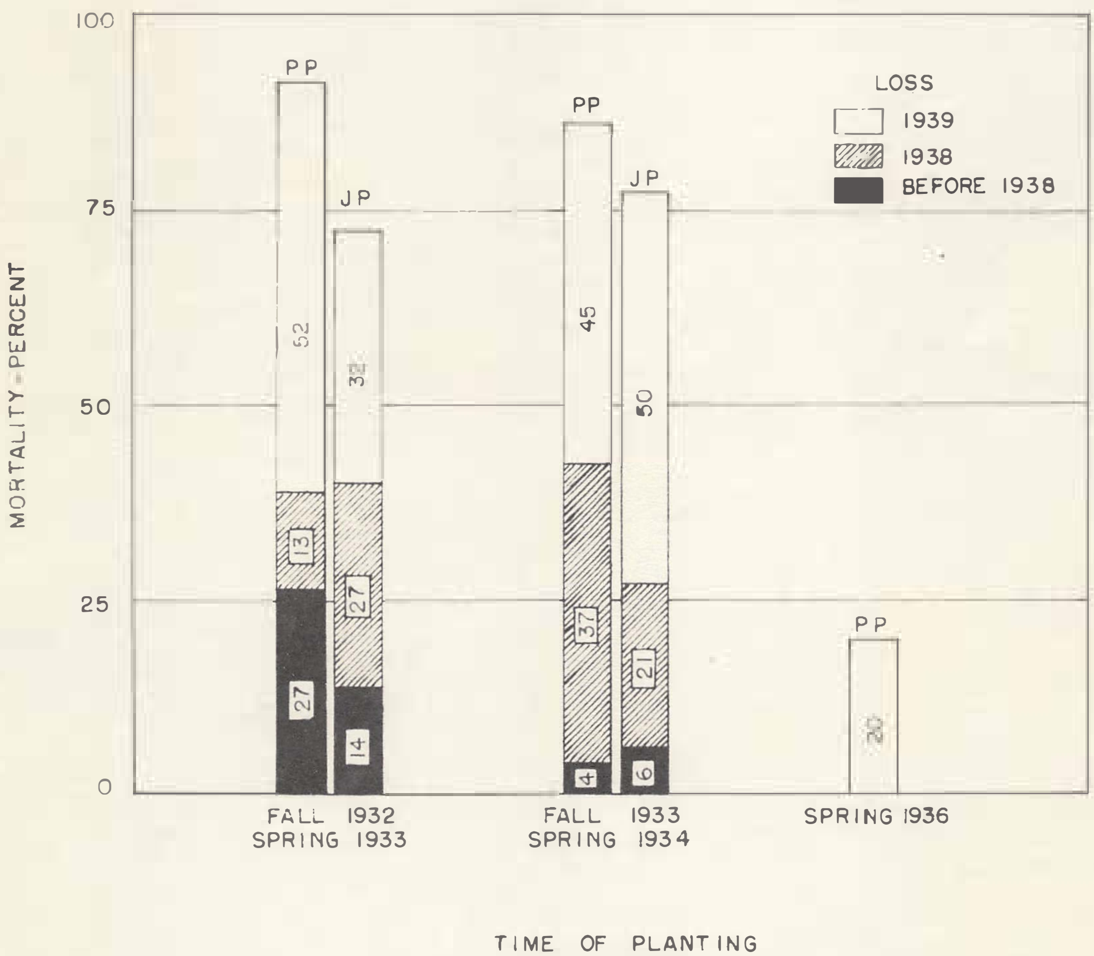


Table 4. Summary of Cylindrocopturus Loss Surveys, 1939,
Big Springs Plantation, Lassen National Forest

Date of Planting	Number of Trees in Sample	Total Killed Number	Total Killed Percent	Killed 1939 Number	Killed 1939 Percent	Killed 1938 Number	Killed 1938 Percent	Killed prior to 1938 Number	Killed prior to 1938 Percent
				Ponderosa Pine					
Fall '32 Spring '33	71	65	91.5	37	52.1	9	12.7	19	26.7
Fall '33 Spring '34	100	86	86.0	45	45.0	37	37.0	4	4.0
1936	50	10	10.0	10	10.0	0		0	
1937	50	0		0		0		0	
				Jeffrey Pine					
Fall '32 Spring '33	79	57	72.2	25	31.6	21	26.6	11	14.0
Fall '33 Spring '34	100	77	77.0	50	50.0	21	21.0	6	6.0
1937	50	0		0		0		0	

Other than being centered in the older plantings, the injury is not confined to any particular part of the plantation. Infested trees may be found over the entire planting, and there is no evidence that the infestation is greater near the margin of the timber than anywhere else in the brushfield. The 1932-33 plantings are centrally located, and have probably served as one of the distributing centers for the weevil population once the infestation started. Natural reproduction in the surrounding forest contains occasional infested trees of approximately the same size as infested planted stock. Evidence in the form of previously killed trees indicates that damage in natural reproduction has occurred sporadically and to a minor extent for some time past.

Burney Springs Plantation

At Burney Springs, 15 miles airline northwest of the Big Springs brushfield, evidence of the presence of Cylindrocopturus has been found, both in the plantings and in natural reproduction. Several dead seedlings, collected by members of the California Forest and Range Experiment Station from within the experimental tract, contained brood of the weevil. No other weevil-killed trees were found in a brief fall survey made of the

various plantings. However, it is considered that the weevil is a potential source of danger in this locality as well as at Big Springs.

Natural Areas

When reports first appeared late in 1938 of injury to planted stock by the weevil which later proved to be *Cylindrocopturus longulus*, no previous records of the species having caused this sort of damage had been made. Thus it was at first thought to be playing a new role in attacking and killing pine reproduction. More intensive observations have shown that the insect has been killing reproduction in natural areas in very limited amounts for some years past, but has escaped notice. Dunning's comment "......increasing intensity of observation tends to disclose natural seedling enemies that are obscure in the wild state" seems to be borne out very well in this case. As mentioned above, the damage has been found in natural reproduction near both brushfield plantings in the Hat Creek area. That its distribution is not confined to the vicinity of brushfields is shown by the fact that in twelve out of twenty-one 20-acre survey plots examined in the Burney area, weevil injury was found (Figure 16). These records reveal that the species is present in the Goose Creek, Burney Creek and Hat Creek drainages. It was also found on the 320-acre survey plot L-12 on the Lassen plateau east of the Hat Creek rim. Thus the distribution of the insect is far wider than was hitherto thought to be the case. Why it should have increased as abundantly as it has in the Big Springs plantings has not yet been satisfactorily explained. However, its successes in attacking planted stock are not dissimilar to the successes of other insects in pure plantations in the east. Experience has shown that plantations are particularly vulnerable to the attacks of insects which in the natural state cause minor damage.

CONTROL

In the light of present information the eradication of infested stock at Big Springs before the brood emerges in the spring seems to be the only feasible means of attempting to control this insect. While this measure should bring about a reduction in the weevil population, it can at best bring but temporary relief so long as the weevil is present in natural reproduction adjacent to the brushfield. Since it is a native insect, and has bred up from these areas in the present instance, there is little reason for believing that it will not do so again in the future. Continuation of attacks, even though to a much lesser degree, following the eradication of the present infestation, will make necessary annual maintenance control until the trees have outgrown the weevil menace.

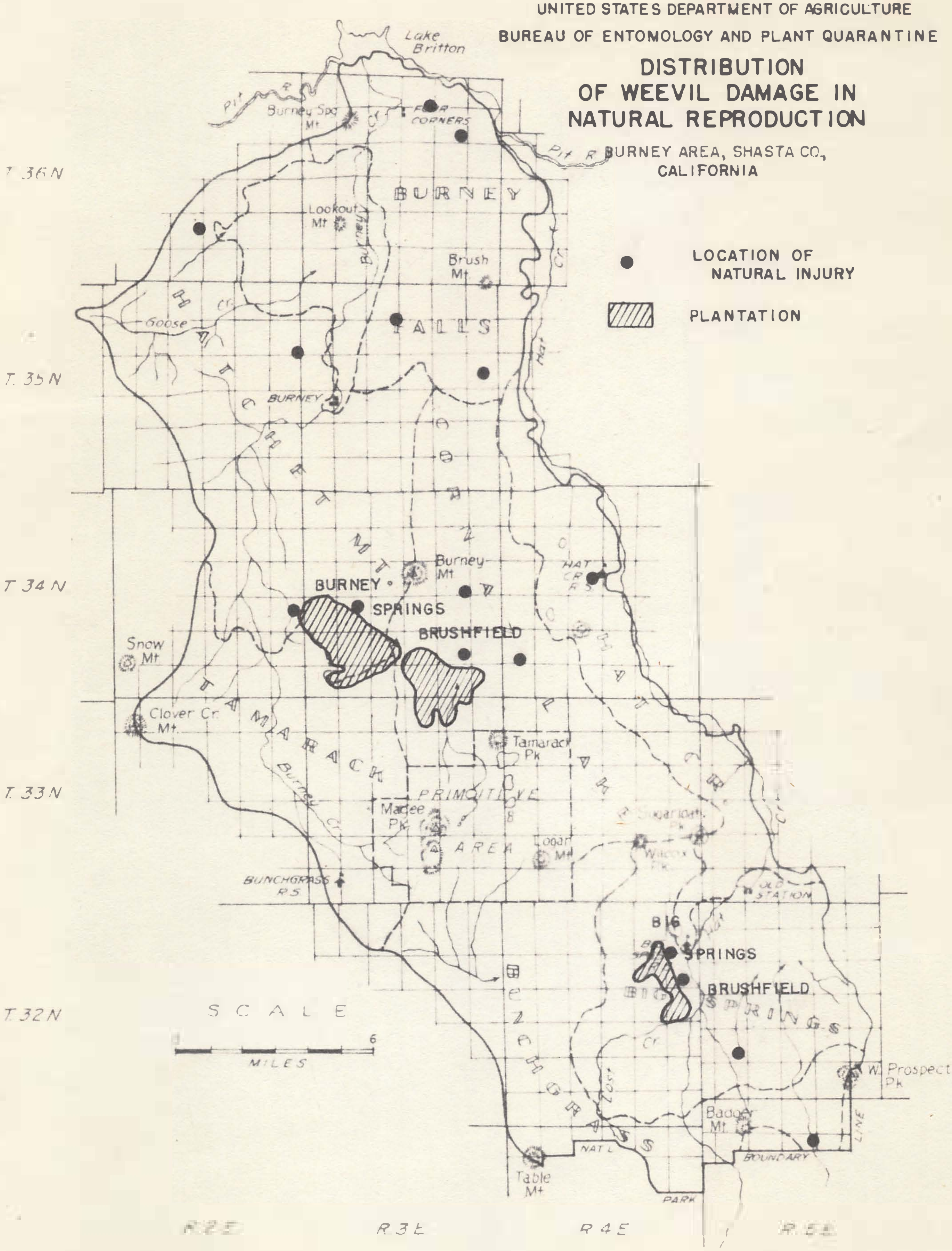
Inasmuch as part of the brood develops slightly below the ground surface, it will be desirable to pull up the smaller trees. The larger trees may be severed below the ground surface with a mattock. A rough survey of

Figure 16

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

DISTRIBUTION OF WEEVIL DAMAGE IN NATURAL REPRODUCTION

BURNEY AREA, SHASTA CO., CALIFORNIA



the Big Springs plantings completed late this fall indicated that the weevil damage was sufficiently widespread to necessitate complete coverage of all plantings if control measures are to be applied. An estimated 130 man days of labor will be necessary to complete this work. Eradication of infested material should be finished by May 1, 1940.

FUTURE INVESTIGATIONS

While the studies of the current season have uncovered a considerable amount of new information on the weevil problem, much remains to be done. Further investigations along the following lines are considered desirable on this problem:

1. Additional studies of the life history of the weevil from a more quantitative standpoint.

2. Repetition of forced attack studies, particularly on Douglas fir and perhaps on white fir and sugar pine.

3. Study of the weevil-fungus association with the object of fixing the responsibility for the injury, probably through the inoculation of healthy trees with the fungus. In this work cooperation with the Office of Forest Pathology will be desirable.

4. Investigation of the soil moisture relationships between brushfield and forested areas to determine whether any differences exist between the two. This work can be carried out in conjunction with the Climate and Loss study.

5. Study of the possibilities of control or prevention of *Cylindrocopturus* injury on planted stock through the use of chemicals.

In addition to the above investigations on *C. longulus*, it will be desirable to make one or two surveys of existing plantations in the northern part of the state during the season of 1940 with the object of finding out what is present, on a quantitative basis, in the way of insect injury. The Hat Creek Forest Insect Laboratory could well serve as a center for the rearing of insects collected in plantings and on natural reproduction.

SUMMARY

1. Following reports of insect injury to 6 and 7 year old pine transplants in the Big Springs brushfield, Lassen National Forest, in 1938, preliminary investigations during the season of 1939 disclosed that the weevil *Cylindrocopturus longulus* Lec. was responsible for the damage.

2. Published and unpublished records on this weevil reveal that it is not a new insect, but has been known for some time, although this is the first occasion where it has been found to be causing damage to plantings. The species is extremely variable both in markings and habits.

3. Partial records of weather and site factors taken by the California Forest and Range Experiment Station in previous years do not provide a basis for linking these factors with the injury.

4. The insect involved is a small gray and white weevil. A description of the life stages is given.

5. The weevil overwinters in the larval stage, pupates in the spring and emerges during June. Oviposition takes place early in July, and the larvae mature by late fall. Three instars occur in the larval stage.

6. Injury is caused both by the feeding of the adults and by the mining of the larvae in the stems and twigs. The latter is by far the most serious.

7. The balance of the evidence indicates that the species is not a gall former as previously reported.

8. The most important organism associated with the weevil is the fungus Hormiscium gelatinosum Hedgc., a blue stain of economic importance in the lumber industry. The pathogenicity of the fungus has not been demonstrated.

9. Forced attack studies show that C. longulus is capable of killing healthy trees 7 times out of 10. Mechanical injury to the host does not seem to be correlated with subsequent success of attack.

10. Surveys of the Big Springs plantings show that to date over 90 percent of the ponderosa pine and 70 percent of the Jeffrey pine in the 1932-33 plantings have been killed. Younger plantings have not suffered as heavily.

11. That the weevil is a native insect is indicated by the presence of injury, both recent and old, in natural reproduction generally over the Hat Creek area.

12. Some relief from future injury in the Big Springs plantings may be expected if infested trees are eradicated.

13. Further investigations on the life history and control of the weevil are necessary.

ADDENDA

Information received since this report was prepared indicates that the use of the name *longulus* for the species of *Cylindrocopturus* affecting ponderosa pine and Jeffrey pine is questionable. In recent correspondence Mr. L. L. Buchanan, Division of Insect Identification, states "Though (the) pine species is different from the fir species, I cannot at present say what name should be applied to either." For want of other designation the species name *longulus* has been used throughout this report.

List of Parasites of *Cylindrocopturus longulus*

Chalcidoidea	*Eurytoma tomici* Ashm. *Rhopalicus pulchripennis* (Cwfd.) *Tetrastichus* sp. *Zagella* sp.	Determined by A. B. Gahan
Proctotrupoidea	*Telenomus* sp.	Determined by C. F. W. Muesebeck

REFERENCES

Becker, W. B. 1939 Larval development of the native elm bark beetle, Hylurgopinus rufipes (Eich.), in Massachusetts. Jour. Econ. Ent., 32(1):112-120.

Bedard, W. D. 1933 The number of larval instars and the approximate length of the larval stadia of Dendroctonus pseudotsugae Hopk., with a method for their determination in relation to other bark beetles. Jour. Econ. Ent., 26(6):1128-1134.

Doane, R. W., E. C. Van Dyke, W. J. Chamberlin, H. E. Burke 1936 Forest Insects, McGraw-Hill Book Co., N.Y. p. 246.

Dunning, D. 1938 Memorandum for T. D. Woodbury, Region 5. Dec. 19, Cal. For. Expt. Sta., (MS)

Furniss, R. L. 1939a Memorandum regarding the cause of dying Douglas firs in the prairie region of the Puget Sound basin--Season of 1939. Forest Insect Laboratory, Portland, Oregon (MS).

__________ 1939b Biology of Cylindrocopturus longulus, Third Quarterly Report, Forest Insect Laboratory, Portland, Oregon. (MS).

Keen, F. P. 1928 Insect enemies of California pines and their control. Cal. Dept. Nat. Resources, Bull. 7, p.72.

Rumbold, C. T. 1939 Preliminary report on Jeffrey pine seedlings infested with the weevil Cylindrocopturus longulus Lec., Bureau of Plant Industry. (MS).

Salman, K. A. 1934 Larval stadia of the western pine beetle. Forest Insect Laboratory, Berkeley, Calif. (MS).

__________ 1939 Forest Insect infestation at Big Springs plantation, Lassen National Forest, California. Forest Insect Laboratory, Berkeley, Calif. (MS).

Salman, K. A. and J. W. Bongberg, 1936 Results of further work on determination of head measurements of the several larval stadia of the western pine beetle. Forest Insect Laboratory, Berkeley, Calif. (MS).

Van Dyke, E. C. 1930 New Rhynchophora (Coleoptera) from western North America. Pan-Pac. Ent., 6:153-158.

Zentmyer, G. A. 1939 Memorandum on Big Springs plantation, Bureau of Plant Industry. (MS)